Engineering Analysis of the FCC Order on Remand

Sean Haynberg
Director of RF Technologies

David Stern
Vice President

Dominic Villecco
President

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1 Introduction & Background

V-COMM has prepared this report and provides an engineering analysis of the technical issues and statements made within the FCC's Order on Remand (Order), with regards to the AirCell waiver.[1] In this Order, the Wireless Telecommunications Bureau affirms its granting of AirCell and its cellular licensee partners waivers of section 22.925 of the Commission's rules.

Within the Order, the FCC provides its explanation to the courts, and the record, for reasons it concluded that AirCell operations do not cause harmful interference to cellular operations, including its methods of determining harmful interference and establishing an interference tolerance level (ITL) relative to analog cellular systems.

In this document, V-COMM examines technical statements made within the Order, and provides additional analysis pertaining to the compatibility of the AirCell system.

V-COMM, L.L.C. is a full-service engineering and consulting firm fulfilling the needs of the wireless telecommunications industry since 1996. Biographies of key individuals contributing to the report as well as an overall profile of V-COMM, L.L.C., are included in the Appendix Section 7.1 of this document.

Through significant and comprehensive compatibility testing, V-COMM has gained specific knowledge of the compatibility issues associated with the AirCell system and its impact to the terrestrial cellular system. V-COMM is serving as an expert third-party engineering firm in evaluating these system compatibility issues, and is retained by a consortium of cellular companies composed of AT&T Wireless, Cingular Wireless, and Verizon Wireless.

[1] The FCC Remand on Order (FCC 02-234) was released on Feb. 10, 2003, in the matter of the AirCell Petition, Pursuant to Section 7 of the Act, for a Waiver of the Airborne Cellular Rule.

2 Overview of Engineering Analysis

In analysis of this Order, V-COMM has reviewed technical documents submitted in the record prior to the granting of the original AirCell waiver, reviewed past and new AirCell system compatibility test data, and provides engineering analyses pertaining to the compatibility of the AirCell system.

This Order allows AirCell and its Partners to continue providing service pursuant to technical restrictions placed upon its use, as provided in the AirCell Bureau Order and Memorandum Opinion and Order (AirCell MO&O).[2] This waiver is predicated on the FCC's belief that no harmful interference is caused to the primary users of cellular spectrum, the terrestrial cellular customers.

In this document, V-COMM provided engineering analysis regarding the Commission's assessments of interference tolerance levels, thresholds for determining harmful interference, reliance on flawed and inadequate flight test data, and lack of consideration of measurement data in its analysis.

In addition, V-COMM provided references to measurements in the record, and new data being submitted into this proceeding for the Commission's review. These include signal level measurements, noise floor measurements and cross-interference test measurements for analog cellular systems.

We believe that in light of the measurement data in the record and the new data being supplied into this proceeding, the Commission should re-evaluate its position on the compatibility of the AirCell system and the protection required for analog cellular systems against harmful interference.

V-COMM also provided analysis of other technical issues addressed in the Order. These include the FCC's analysis of "mean" AirCell signal levels, Airtouch's derivation of ITL, the worst-case compatibility scenario, AirCell's DPC not lessening concerns of interference, and the need for a consistent framework for judging harmful interference.

[2] AirCell Bureau Order, 14 FCC Rcd. 806 (WTB 1998), and AirCell MO&O, 15 FCC Rcd. 9622 (2000).

3 Assessment of ITL and Harmful Interference for Analog Cellular Systems

The central issue of the Order addresses the FCC's method for determining harmful interference and the interference tolerance level (ITL) pertaining to terrestrial analog cellular service. These methods did not rely upon actual measurements in the record or in the industry to support or arrive at its interference tolerance level. Instead, the FCC derived its ITL based upon unsubstantiated values in technical literature, and others taken out of context, which are not consistent with measurements reported by AirCell and the carriers in the record.

In the FCC's assessment of ITL and harmful interference it did not include an analysis of the operating signal levels and noise floor levels of cellular systems. Significant measurements are in the record, and also are submitted to the FCC in this proceeding. With these noise floor conditions, cellular service is provided at very low operating levels to customers that operate with increased path losses in rural areas and inside buildings. The FCC should account for protection of these cellular services in determining ITL and harmful interference thresholds.

For these reasons, the FCC should not use the ITL and harmful interference thresholds that were applied in the Order, and only consider thresholds that are supported by substantial measurement data with appropriate tests in the cellular markets using typical operating conditions.

3.1 FCC's Derivation of Interference Tolerance Level

Within the Order, the FCC defines ITL as "the highest level of noise and interference power that can be received by a cellular base station receiver without any interference being caused to the weakest telephone call that could still be considered an acceptable quality call."[3]

The Commission derived its ITL based upon the formula:

$$ITL = C_{min} - R \qquad \text{Equation 1}$$

Where: ITL is the interference threshold power in dBm
C_{min} is the minimum signal necessary for a good quality call, in dBm
R is the ratio of signal to noise-plus-interference (S/N+I, or C/I), in dB

In applying Equation 1, the Commission used the values –100 dBm for (C_{min}) and 17 dB C/I for (R) to derive an ITL of –117 dBm for rural areas as the basis for its interference

[3] Order on Remand, at Pg. 2 and Pg. 6.

analysis pertaining to analog (AMPS) cellular service. The Commission states that these values are based upon technical parameters that are generally accepted in the industry and are well within the range of values in the record. The FCC states the –100 dBm minimum call level is consistent with AirCell's and AT&T Wireless' value submitted in the record, and with Dr. Lee's and Dr. Rappaport's published textbooks.[4]

However, it should be clarified that these references are not appropriate in the context of a minimal analog call signal level with acceptable quality. In Dr. Lee's textbook, the -100 dBm level pertains to the minimum handoff setting that operators utilize to maximize performance on their network and maintain calls on the closest base station. In Dr. Rappaport's textbook, the reference is also within the section of handoff issues, and only provides a very short, generalized and unsupported reference to this level. It should be regarded that while these textbooks are widely used in university classes and as general technical references, the minimum signal level values referenced by the FCC are not indicative of operating conditions in current cellular networks.

Dr. Rappaport also refers to a minimum C/I threshold for analog call quality of 18 dB, which is different than the FCC's 17 dB C/I threshold. Dr. Lee also considers 18 dB as the minimum C/I threshold for acceptable call quality. The FCC did not agree with these two industry sources for minimum quality threshold for analog calls.

Regarding the FCC's reference of AT&T Wireless' statements in the record, the FCC did not include statements that AT&T Wireless represented the minimum call level at -107 dBm and used a 6.6 dB network reliability margin, to reach a –100.4 dBm threshold for call level and signal margin.[5] In the Order, the Commission considers network reliability factors that compensate for signal fading reasonable engineering practice,[6] however the FCC did not include such a factor in its derivation of ITL.

If the Commission used AT&T Wireless' network reliability factor of 6.6 dB, in addition to the required C/I of 17 dB (for a total signal and reliability margin of 23.6 dB), the commission's ITL threshold would be –123.6 dBm.[7] This ITL threshold is similar to the ITL thresholds advocated by AT&T Wireless, Airtouch & Dr. Lee.[8] The FCC did not agree with these ITL thresholds advocated by the carriers in the record.

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[4] It should be noted that the adoption of the original AirCell Order (AirCell waiver) occurred prior to the referenced textbook of Dr. Rappaport, published in 2002 (first edition in 1999).

[5] These values are provided in AT&T Wireless' submitted comments to the Commission in its document entitled *AirCell Impact on AT&T's Terrestrial Cellular System Waurika/Madill Tests on July 10-11, 1997,* (Dated Dec. 15, 1997, Section 6, Pg. 9). This report was attached as Appendix A to the "Opposition of AT&T Wireless Services, Inc. to Petition of AirCell, Inc.," filed 12/15/97.

[6] Order on Remand, at Pg. 9, footnote 50.

[7] This threshold is 6.6 dB lower than the FCC's ITL threshold derived in its Order.

[8] Airtouch & Dr. Lee's ITL threshold is –124 dBm, which is similar to AT&T Wireless' ITL threshold of –123 dBm.

3.2 Measurements of Signal and Noise Floor Levels

In the FCC's assessment of ITL and harmful interference it did not include an analysis of the operating signal levels and noise floor levels of cellular systems. With these noise floor conditions, cellular service is provided at very low operating levels to customers that operate with increased path losses in rural areas and inside buildings.

The FCC did not consider AT&T Wireless' signal level measurements that were recorded and submitted in the record at that time for analog cellular base stations.[9] These measurements indicate that approximately 30% of wireless calls are received below –100 dBm, and approximately 20% of wireless calls are received below –105 dBm. These reverse-link measurements were conducted on a variety of cells (approx. 10 cells in total, including suburban and rural), within its Sherman-Denison MSA market.

Also, the FCC did not consider AT&T Wireless' signal level measurements that were recorded and submitted to the Commission, as provided in an engineering statement by V-COMM.[10] In these measurements, AT&T Wireless measured customer signal levels at a dense urban cell site in Manhattan, NY, showing that even in this dense urban market approximately 55 minutes of usage is served below –100 dBm, as measured on a single sector of a cell site over a 3 hour time period. Multiply this occurrence over all AT&T Wireless' cell sites in Manhattan and it translates to tens of thousands of minutes of use by AT&T's customers, for the same time period. Even in dense urban markets, a significant amount of traffic is handled below –100 dBm. These signal levels represent acceptable quality calls when low noise floor conditions occur at dense urban base stations. Low noise floor conditions occur during periods of lower network loading and in cases where base station antennas are mounted at lower elevations within the clutter of the buildings.[11]

In addition to these measurements in the record, V-COMM performed measurements at a typical suburban base station within the Trenton, NJ MSA and recorded approximately

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[9] This signal measurements were provided in AT&T Wireless' submitted comments to the Commission in its document entitled *AirCell Impact on AT&T's Terrestrial Cellular System Waurika/Madill Tests on July 10-11, 1997,* (Dated Dec. 15, 1997, Section 6, Pg. 9-10, Figure 8).

[10] On behalf of AT&T Wireless, Cingular and Verizon Wireless, V-COMM submitted an ex parte document entitled *Engineering Statement on AirCell to Terrestrial Cellular Compatibility* (Engineering Statement) to the Commission on April 4, 2000, for consideration of compatibility issues associated with the AirCell system. Within the Engineering Statement, V-COMM provided that AT&T Wireless measured customers receive signal levels below –100 dBm to 2% of its analog traffic. This signal level is referenced to the input of the cell site, which is the common reference point for all base stations. V-COMM reports and statements reference this common point.

[11] In mature cellular systems in dense urban markets, the base station antennas are usually mounted at lower elevations, i.e. 2nd story elevations, side of buildings, light pole structures, etc.

45% of the customer traffic for analog service is served at or below –100 dBm level.[12] This percentage of calls was representative of other cell sites in the surrounding suburban area. Cell sites in rural markets serving larger coverage areas can exhibit even higher percentage of calls below the –100 dBm level.

For these reasons, V-COMM strongly disagrees with the Order's assertion that the minimum acceptable call signal threshold is –100 dBm. This level is not accepted within the industry, nor supported by actual field measurements. To better understand the cellular radio environment, the Commission should undertake measurements of actual customer signal and noise levels to determine appropriate thresholds for interference tolerance and protection of cellular service from harmful interference.[13]

In a comprehensive AMPS Noise Floor Study,[14] V-COMM measured the noise floor at 18 AMPS terrestrial sites in the New Jersey and Pennsylvania area, for sites in dense urban, urban, suburban and rural market type environments. In these test results, the noise floor level observed at suburban and rural sites (and some urban sites, as well) was measured to –127 dBm.[15] At these levels, AMPS customers can maintain calls to –110 dBm with acceptable voice quality (i.e. 17 dB C/I).[16] This is the minimum signal level that AMPS calls can be handled by the cellular system (i.e. –110 dBm). This level is 10 dB below the Commission's minimum call level with acceptable quality.

It also should be noted that similar low noise floor conditions were measured and provided by AirCell in its 1997 filings.[17] However, the Commission did not recognize

[12] As submitted to the Commission on April 10, 2003, in the report entitled "Engineering Report of the AirCell Compatibility Test", V-COMM provides these measurements within its Phase 2 Test Results, for AMPS Terrestrial Customer Signal Levels.

[13] The FCC's Spectrum Policy Task Force and Technical Advisory Counsel also recommends the Commission undertake noise floor measurements to understand the radio environment to aid in determining harmful interference.

[14] The *AMPS Noise Floor Study* is submitted to the Commission on April 10, 2003, within an appendix section of the report entitled "Engineering Report of the AirCell Compatibility Test" into the FCC's comment proceeding regarding AirCell's petition for waiver extension.

[15] The median operating noise floor levels, averaged per market type, for Dense Urban, Urban, Suburban and Rural sites are measured to –123.4, –126.2, –127 and –127 dBm, respectively.

[16] In the presence of considerable signal fading, an additional fade margin may be required. However, most cellular systems utilize diversity receive path systems, which mitigates the effects of signal fading. These systems can provide between 2.7 to 5.7 dB of mean signal improvement depending on the radio environment, over cellular systems not employing such technology. Refer to *AMPS Noise Floor Study* for more information on diversity systems.

[17] In AirCell's 1997 Report to the Commission, it provided measurements of very low noise floor conditions existing at terrestrial cell sites. For example, in its Figure 9 Waurika Reverse Channel Noise Floor Histogram (24 Hours), almost all data shows the terrestrial noise floor at –131 dBm. This figure is reproduced for reference in V-COMM's *Engineering Response to AirCell's Petition for Waiver Extension* (filed in this proceeding on 4/10/03), in Figure 4-B AirCell Measured Terrestrial Noise Floor Levels (From AirCell 1997 Report).

these low noise floor conditions when deriving its interference tolerance thresholds for analog cellular systems.

In its criticism of Airtouch & Dr. Lee's ITL threshold, the Commission states that it "[does] not regard it as reasonable to assume that a cell site will experience zero environmental noise."[18] However, the FCC did not consider the actual field measurements in the record (these are similar to measurements recently recorded by V-COMM), which support that zero or near-zero environmental noise conditions *do* occur at terrestrial base station receivers for the majority of the measurements.

These terrestrial noise floor conditions are made possible by the base station antenna's vertical beam width characteristics and antenna mounting location. For example, in reviewing a common cellular panel antenna's (i.e. the Decibel Products Antenna Model DB874H83) vertical beam width characteristics for angles below -25 degrees (0 degree reference at horizon), the environmental noise signals incident from these angles are attenuated by 30 to 70 dB, depending on the incident angle. Since terrestrial base stations employ narrow vertical beam width antennas pointed at the horizon, the environmental noise signals from the surrounding base station area are significantly attenuated. In addition, for environmental noise signals that are within the antenna's 3-dB vertical beam width (typically +/- 7 degrees), that is for noise signals that are propagating from the horizon or a far distance away, these noise levels are also attenuated by a significant propagation path loss that provides significant attenuation to these environmental noise signals. In summary, with the terrestrial base station's antenna filtering characteristics, zero environmental noise is possible, and based upon field measurements it occurs frequently in suburban and rural sites.

With very low operating noise floor conditions and acceptable call quality thresholds, a significant amount of cellular traffic is handled between –100 dBm to –110 dBm, which the Commission should not disregard. V-COMM recorded approximately 35% of customer traffic for analog service being served between –100 and –110 dBm, at a typical suburban base station in the Trenton, NJ MSA. In AT&T Wireless' submitted data in the 1997 record,[19] it measured approximately 20% of its customer traffic at signal levels between –100 and –110 dBm. This represents a significant amount of cellular traffic, which the Commission is not considering since it assumed the minimum call level is –100 dBm. Again, it should be noted that rural sites with larger coverage areas would exhibit even greater percentages of calls within the –100 to –110 dBm levels.

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[18] Order on Remand, at Pg. 8.

[19] This signal measurements were provided in AT&T Wireless' submitted comments to the Commission in its document entitled *AirCell Impact on AT&T's Terrestrial Cellular System Waurika/Madill Tests on July 10-11, 1997,* (Dated Dec. 15, 1997, Section 6, Pg. 9-10, Figure 8). This report is attached as Appendix A to the "Opposition of AT&T Wireless Services, Inc. to Petition of AirCell, Inc.," filed 12/15/97. AT&T's Figure 8 is reproduced for reference in Appendix Section 7.2 of this report.

Calls within these ranges exhibit acceptable voice quality for modern cellular systems with low noise floor conditions. In the *AMPS Noise Floor Study*, V-COMM outlines to the Commission that over the past years, cellular networks have experienced a quieting effect to their operating noise floors for a variety of reasons. [20] These reasons include lower power cellular portable phones, increasing cellular phone use in-buildings, use of narrow horizontal beam width antennas, lower antenna mounting elevations, down-tilted antennas and network parameters designed to lower the operating noise floor allowing calls to be served at lower signal levels with sufficient quality.

For these reasons, the Commission should accept a minimum call level of –110 dBm for suburban and rural markets having noise floors of –127 dBm. Using –110 dBm as the minimum call level and 17 dB C/I for (R) in the Commission's Equation 1, yields –127 dBm for the ITL. Using these values, an ITL of –127 dBm should be the appropriate threshold for interference for analog cellular systems. These are values the Commission should rely upon, which are well supported by extensive field measurements. The Commission should not rely upon values in statements taken out of context, or unsupported references in technical literature.

In addition, the Commission did not consider effects to cellular systems representing worst case conditions. Cellular systems in Quiet Rural market types, or systems that utilize masthead low noise amplifiers or superconductor filter systems are not considered for protection from harmful interference by the Commission's derived method. These systems utilize technology that lowers the noise floor (by approx. 2 dB) and provide cellular service to rural and quiet rural areas with extended coverage ranges outdoors and in-buildings. In some of these areas, no other wireless service or wire line competition may exist. The Commission should protect these deployed systems against harmful interference. Furthermore, cellular operators need assurances that investments and deployments in their networks to improve service for customers are not defeated by external interference from secondary uses of cellular spectrum.

3.3 FCC's Assessment of Harmful Interference

In the Order, the Commission explained its assessment of harmful interference to analog cellular systems for this proceeding.[21] In its interpretation of the definition of harmful interference,[22] the Commission indicates that interference between –114 to –111 dBm, "could produce objectionable interference resulting in noisy calls that would be annoying [to an average caller]", however these levels are not considered "harmful interference." The Commission states that "harmful interference" is indicated only by a very substantial increase (e.g. 7 dB or more) over their ITL of –117 dBm, which is –110

[20] In Section 6.1 "Cell Site Operating Noise Floor in Today's Cellular Networks" of the *AMPS Noise Floor Study*, submitted to the Commission in this proceeding.

[21] Order on Remand, Pg. 10.

[22] The FCC's definition of harmful interference in its rules and regulations are "interference which … seriously degrades, obstructs, or repeatedly interrupts a radio communication service."

dBm or greater. V-COMM has serious reservations regarding the Commission's threshold for harmful interference, as explained below.

The Commission supported its harmful interference threshold, which relies upon a C/I ratio of 10 dB for acceptable voice quality, by stating that AirCell's consultant stated this interference level will certainly be heard, and AT&T Wireless stated this will result in sustained interference, loss of SAT, and eventually dropped calls. This hardly supports the Commission's reasoning. While this clearly does constitute harmful interference, it is not correct that any lesser amount of interference is non-harmful. The Commission's Order provided no explanation for concluding that interference causing the C/I ratio to degrade to the "objectionable" level, for example, is not harmful interference. The Commission's unsupported interpretation of harmful interference offers no protection against the effects of harmful interference for analog cellular service, and does not serve the public's interest.

Cellular service is used by tens of millions of customers through a network of tens of thousands of cellular base stations, providing extremely important and critical communications services to the public and government agencies. The spectrum supports a growing percentage of landline displaced calls, approximately 35% of 911 emergency calls, and serves as priority access communication systems to government agencies in critical times of homeland security. Interference-free operations for these users are required. The Commission should not jeopardize or degrade these existing licensed services.

For reasons provided in V-COMM's *Engineering Report of the AirCell Compatibility Test*,[23] V-COMM does not believe the AirCell system is compatible with terrestrial analog or digital cellular service, due to observations of significant harmful interference.

Also, regarding the Commission's reasons for assessing an interference tolerance level, it appears illogical and unreasonable to derive an interference tolerance level and use a very different assessment of harmful interference. The Commission also acknowledges that its previous statements in the AirCell MO&O imply the threshold for determining harmful interference is the ITL (–117 dBm, per FCC), and not a level 7 dB higher (–110 dBm).[24]

With a harmful interference threshold of –110 dBm, the Commission assumes analog cellular calls only require 10 dB of C/I to maintain acceptable quality. It should be noted that this threshold is not consistent with the FCC statements in footnote 37 of the Order, which reads: "We note that an (R) value of 13 dB is not comparable to the industry's

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[23] Submitted in this proceeding, April 10, 2003, on behalf of AT&T Wireless, Cingular Wireless and Verizon Wireless.

[24] In the Order, the Commission derives its ITL based upon a minimum call signal level of -100 dBm and a C/I ratio of 17 dB. Further, the Commission does not consider this level harmful interference (i.e. –117 dBm), rather it considers harmful interference at a level that is 7 dB stronger than the FCC ITL, or –110 dBm.

normal design criteria, and we do not believe that it is sufficient to guarantee a good quality call." It seems contrary to reason that the Commission believes 13 dB C/I is not sufficient for a good quality call, and at the same time it believes 10 dB C/I is sufficient to prevent harmful interference. A 10 dB C/I threshold is not consistent with industry accepted practice, nor supported in the record in reference to protection from harmful interference. The FCC should not assume any less than the industry standard for acceptable call quality, which is at least 17 dB. In fact, Dr. Lee and Dr. Rappaport, two experts cited by the Commission in this proceeding, consider the minimum acceptable quality threshold for C/I is 18 dB. Using a 10 dB C/I threshold for determining whether service is acceptable or unacceptable, the Commission is in vast disagreement with its prior statements, all other parties in the record of this proceeding, accepted industry practices, and two experts that were cited by the FCC in its Order.

Other statements in the Order are also inconsistent. In its derivation of ITL, the Commission states it derived ITL by using "the minimum power level needed for a good-quality cellular telephone call, and factoring in a buffer to protect that call." It is not apparent regarding how the FCC considers it "factored in a buffer" to protect cellular calls. It considered a threshold for harmful interference at –110 dBm with 10 dB C/I, and an ITL at –117 dBm with 17 dB C/I. For these thresholds, there are no "buffers" to protect the minimum acceptable cellular call from interference that will render it unacceptable. In addition, the Commission did not utilize network reliability (fading) margins or interference to noise (I/N) ratios to protect cellular calls, as petitioned by wireless carriers in the record.

3.4 Interference Tests with AMPS Technology

In the Order, the FCC considers interference levels up to –111 dBm as an acceptable level of interference to analog cellular systems, which is not indicative of "harmful interference" (per the FCC's definition). V-COMM strongly disagrees with the FCC's threshold for harmful interference, and has recorded extensive interference test results to support that interference occurs at much lower levels.

As measured in V-COMM's AirCell to Terrestrial Cellular compatibility tests for AMPS technology,[25] for an interference signal level of –111 dBm (or 1 dB lower than the FCC –110 dBm limit), the performance degradation was 16 dB decrease in the median C/I ratio, and 0.4 unit decrease in average MOS (Mean Opinion Score),[26] and 1 unit decrease in 90% MOS resulting in "bad" audio quality. At the –111 dBm interference level, the 90% C/I performance degradation is the most significant, which is a key quality and performance indicator for AMPS systems. The 90% C/I performance

[25] As submitted to the Commission on April 10, 2003, in the report entitled "Engineering Report of the AirCell Compatibility Test", V-COMM provides these measurements in Section 4.2, Section 4.5 and Table 4.5-A.

[26] The MOS metric is an accepted industry measure for voice quality, on a scale from 0 to 5 units.

decreased by 15 dB, from the baseline operating level of 20 dB C/I, to a C/I of 5 dB. This represents significant harmful interference for analog cellular systems, which normally requires a 17 dB C/I for 90% of the time.

Other interference test results at lower interference levels also show significant and harmful interference. The lowest level that interference is observed in AMPS tests, is at an interference level of –123 dBm, which lowered the median C/I of AMPS calls by 4 dB. This decrease in C/I is significant and harmful for many AMPS cell sites, including sites with larger coverage areas, with increased in-building cellular use, and rural sites. The AMPS test site used in V-COMM's tests was a typical suburban site (located in the Trenton, NJ MSA), with a coverage radius of approximately 1.5 miles. As described in V-COMM's compatibility test report, this decrease in performance results in harmful interference to AMPS cellular systems. For in-building cellular users, and base stations with larger coverage radiuses than 1.5 miles (i.e. rural sites), the received call level signals should be expected to be closer to the noise floor and would be more sensitive to interference from external sources. In these cases, this performance decrease would indicate a harmful impact to the performance of cellular AMPS systems. In addition, base stations employing tower-top LNA or super conductor filters would be particularly sensitive to external interference that increasing the noise floor.

V-COMM's compatibility tests for AMPS technology did not include rural sites, super conductor filters or tower-top LNA sites. For these cellular applications the threshold for harmful interference is expected to occur at lower interference levels, as compared to the test results with the suburban site. These cellular applications are specifically designed to serve mobiles at weaker levels, and therefore the impact would occur at lower interference levels.

Rural sites (and suburban sites with larger coverage areas) operate at lower signal and noise levels, and would be more sensitive to interference than suburban site utilized in the interference tests described above. They serve a substantial amount of traffic in the –100 dBm to –110 dBm range with acceptable voice quality. As such, these sites should utilize an ITL of –127 dBm, to protect them from harmful interference. This represents the minimum call level of –110 dBm and a C/I of 17 dB. In addition, the –127 dBm level was the measured operating noise level for the majority of cellular AMPS sites tested in the *AMPS Noise Floor Study*. Consequently, the –127 dBm level should be the threshold used for ITL and harmful interference for AMPS cellular systems. At this level, AMPS cellular service should be protected from harmful interference.[27]

[27] For rural sites employing super conductor filters or tower-top LNA equipment, additional protection may be necessary.

4 FCC's Analysis of AirCell System Relies Upon Inadequate Flight Data

As indicated in the FCC waiver, MO&O and Order on Remand for the AirCell system, the FCC's analysis of the AirCell System solely relies upon the 1997 AirCell Flight data. Further, the FCC states that they only considered one of the two days of flight tests in 1997, which was on July 10, 1997.[28] As explained in extensive detail in V-COMM's *Engineering Response to AirCell's Petition for Waiver Extension* (Engineering Response),[29] the July 10th 1997 AirCell Flight Test data is extremely limited flight data and only represents the best case flight path scenario and test conditions.

The 1997 AirCell flight data relies on flight patterns with an airplane flying directly toward and over the top of a terrestrial site. As explained in the Engineering Response, this flight path scenario can only be viewed as best case, due to significant "nulls" in the signal path resulting from the airplane's orientation to the terrestrial site. With this flight path directly over a terrestrial site, the "nulls" in the vertical pattern of the terrestrial antenna are on the order of 35 dB in the upward direction. In addition, other "nulls" in the AirCell VOR antenna pattern[30] and the aircraft's horizontal stabilizer are provided in the direction below the aircraft. The combination of these "nulls" contribute to approximately 50 dB lower signal strength with this flight path orientation to the victim terrestrial site. The flight path utilized in AirCell's 1997 flight tests only represents the best-case scenario. The worst case is flying horizontal to the victim site, as described below, rather than the flight path used on the July 10, 1997 flight tests.

In addition, when the aircraft is flying toward or away from the victim terrestrial site, the "reduced gain" in the horizontal pattern of the airborne AirCell VOR mobile antenna contributes to approximately 8 dB lower signal strength with this flight path orientation to the victim terrestrial site. Also, when the aircraft is flying directly toward the victim terrestrial site, the AirCell signals are blocked and reflected by the aircraft's fuselage at these incident angles to terrestrial sites. These flight paths were used in the 1997 tests,

[28] The Commission rejected the July 11, 1997 flight test data because the AirCell system did not use dynamic power control, and instead used AirCell mobiles at fixed maximum power of 75 mW per FCC waiver limits. The FCC does not consider the July 11th test data are representative of the AirCell system, however they fail to recognize that AirCell systems utilizes their maximum power levels and these levels should be studied to understand the interference potential of the AirCell system.

[29] As submitted to the Commission on April 10, 2003, in the report entitled "Engineering Response to AirCell's Petition for Waiver Extension", V-COMM provides a detailed analysis of 1997 AirCell Flight Test Data.

[30] The AirCell VOR mobile antenna was used in the 1997 flight tests. After 1997, AirCell offered a second type of mobile antenna that does not mount on the aircraft vertical stabilizer. Instead, the new mobile antenna mounts on the belly of the aircraft, which has direct line of sight below the aircraft.

and results in significantly lower signals received at the terrestrial sites, which represents a best case (least interference) flight path scenario.

AirCell's statements in its petitions and reports characterizes the 1997 flight path as worst case when it actually represents a best-case flight path scenario, as explained above. The worst case orientation to the victim terrestrial site involves reviewing the associated gain factors in the horizontal & vertical antenna patterns of the AirCell VOR mobile & terrestrial base station, in addition to the shadowing effects of the AirCell VOR antenna for the individual aircraft. As explained in the Engineering Response, this depends on the type of aircraft, type & mounting of AirCell mobile antenna, the altitude of flight, orientation to victim terrestrial site, and type terrestrial antenna. It would entail the aircraft orientated broadside to the terrestrial site, with the aircraft in the main horizontal & vertical beam of the terrestrial antenna, and at a distance away that allows signal path to be unobstructed by the horizontal stabilizer of the aircraft.

In addition, the worst case scenario is with victim terrestrial base stations that utilize horizontal or slant-45 type polarity antennas. These polarities receive AirCell signals at stronger levels, since AirCell mobile signals are horizontally polarized. The 1997 AirCell tests attempted to capture horizontal polarity test data however these readings were unreliable, as provided by AirCell in its 1997 report.[31] Consequently, the 1997 AirCell test data only provides useful insight into the best case scenario of a victim terrestrial site employing a vertically polarized antenna.

Many terrestrial cellular operators are deploying dual-polarity antennas to meet market demands and network objectives.[32] This trend is expected to continue into the foreseeable future, and represents an increasing compatibility issue with the cellular spectrum-sharing AirCell operation that utilizes horizontally polarized antennas.

To assess the compatibility of the AirCell system the Commission should analyze the V-COMM flight test data, which is submitted in this proceeding. These include significantly more flight patterns, more variation in flight altitudes and orientation to terrestrial sites, and more terrestrial antenna types (vertical, slant 45 and horizontal polarity). The V-COMM flight data represents extensive testing and accurate ranges of received AirCell signal levels at terrestrial cellular systems. These results must be considered for the FCC's analysis of the compatibility of the AirCell system.

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[31] The following statement is noted by the test instrument operator from the 1997 flight tests, and is referenced to the AirCell 1997 Report, pg. 34. *"Note that the coaxial cable (provided by BellSouth) used to connect the Grayson receiver to the Horizontally Polarized panel antenna at Waurika was found to be intermittent when swept. This Horizontal polarization data is therefore unreliable, and is included on the data CD for completeness only".*

[32] Cingular Wireless plans to install approximately 45,000 dual polarity type antennas over a two-year period, throughout their nationwide cellular network. On August 8, 2002, the FCC has announcement modifications to its cellular rules that include the elimination of the requirement for electromagnetic waves radiated by transmitters to be vertically polarized.

After reviewing V-COMM's extensive flight test data, along with its AMPS interference test results and case study provided in the *Engineering Report of the AirCell Compatibility Test*, it is evident that continued commercialization of the AirCell system is not warranted. In reviewing these test results, it can be determined that substantial harmful interference is occurring to the terrestrial AMPS cellular networks.[33] Therefore, it is not in the general public's interests to continue operations pursuant the AirCell waiver. The AirCell system and operation does not provide sufficient protection to the primary user of cellular spectrum.

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[33] As depicted in a case study in the "Engineering Report of the AirCell Compatibility Test", the impact of a typical flight can potentially cause harmful interference to over 200 AMPS terrestrial sites and 200 AMPS terrestrial telephone calls. This utilizes an interference analysis point of –114 dBm, showing an AMPS service degradation of 12 dB in median C/I, 0.2 unit decrease in MOS audio quality, and the 90% C/I degradation to a C/I of 10 dB, for a typical suburban site with 1.5 mile coverage radius.

5 AirCell System Causes Harmful Interference to Analog Cellular Systems

During the months of December 2000 to July 2001, V-COMM conducted extensive flight tests of the AirCell system.[34] These flight tests included a variety of flight patterns and altitudes, two different types of AirCell mobile antennas, four different types of terrestrial cellular antennas, three different terrestrial base stations, and two types of airplanes. As noted in V-COMM's Engineering Response, this flight data represents significantly more flight data than the 1997 tests. In addition, the V-COMM flight data includes flight patterns and signal levels that are more representative of the range of levels that can be expected in typical cases.[35]

Prior to the planning stages of these flight tests, V-COMM along with other cellular operators encouraged AirCell to participate in this testing effort. This offer was not accepted, however it should be noted that AirCell did cooperate in the following respects. AirCell agreed to verify the AirCell mobile phones utilized in the testing were installed and operating accordingly to AirCell specifications, and AirCell configured and optimized the AirCell base station utilized in the testing.

In reviewing the V-COMM flight test results, the range of signal levels received at the terrestrial sites is between –72 dBm to –130 dBm for all data, and is frequently in the –90 to –110 dBm range. The received signal range is between –72 dBm to –90 dBm in some of the cases when the AirCell mobile is at maximum transmit power (75 mW, per FCC waiver limits) and within 20 miles of the victim terrestrial site. Terrestrial antennas utilizing horizontal or slant-45 degree polarization received the highest signal strengths, since AirCell signals are horizontally polarized. With these terrestrial antenna deployments the received interference from airborne AirCell phones is particularly harmful to cellular networks. Slant 45 and horizontally polarized antennas are being used on a growing basis in terrestrial networks for a variety of reasons. This represents a compatibility issue for AirCell operations that will get worse.

Once the Commission reviews the new flight data provided in the V-COMM report, it should conclude that the current AirCell system does not offer sufficient protection against harmful interference for cellular networks. Even using the Commission's threshold for determining harmful interference, identified in its Order as –110 dBm, significant occurrences of received signal levels are significantly above this threshold (i.e. from –72 to –110 dBm), as measured at terrestrial cellular base stations.

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[34] As submitted to the Commission on April 10, 2003, in the report entitled "Engineering Report of the AirCell Compatibility Test", V-COMM provides measurement results of the extensive flight testing of the AirCell system, referred to as Phase 1 tests.

[35] The 1997 AirCell flight data that the FCC and AirCell relied upon only includes the best case flight scenario, i.e. with the aircraft utilizing the AirCell VOR mobile antenna flying directly toward and over a victim terrestrial site that used a vertically polarized antenna.

Using the FCC's threshold for harmful interference for analog cellular systems, it can be demonstrated that significant harmful interference will occur to many cellular sites along a typical flight path. For the case study flight profile that was described in the *Engineering Report of the AirCell Compatibility Test*, and using an interference threshold of –110 dBm, it is observed that a significant number of co-channel analog cellular sites would experience harmful interference along this typical flight path. As provided in Appendix Section 7.3 of this report, the number of co-channel analog cellular sites meeting or exceeding this threshold for the slant-45 degree terrestrial antenna is 43 cell sites.[36] Also, using the same case study and the 90% AirCell signal levels received at the terrestrial sites, yields 185 cell sites with harmful interference.[37]

Based upon the V-COMM flight test data and the FCC's threshold for determining harmful interference, the Commission should conclude that AirCell operations exceed this threshold by a considerable margin. Thus, the Commission's assessment of the compatibility of the AirCell system should conclude it causes harmful interference to cellular service, which is the primary service in the cellular band. For these reasons, the FCC should not allow the AirCell system to continue operations in the cellular band.

In addition to reconsidering its assessment of the AirCell system, the Commission should provide a consistent framework for judging harmful interference and clarify its rules and regulations prior to the consideration of new spectrum-sharing services.

[36] This analysis uses the average AirCell signal level received at co-channel terrestrial analog cell sites employing the standard N=7 frequency reuse network design, along a flight path between Teterboro, NJ airport and Washington Dulles airport. Also, this number of affected terrestrial cell sites would increase as the analog frequency reuse is increased.

[37] The 90% AirCell Signal Level represents the 90th percentile of measured signal levels for each 1 mile interval from the terrestrial site. In other words, 90% of the recorded signal strength readings are at or below this signal level, and 10% of the readings are above this level. This uses a standard statistical representation for a normal distribution of data points.

6 Other Technical Issues Regarding the Order

6.1 FCC's Analysis of "Mean" AirCell Signal Levels is Technically Flawed

In its Order, the FCC refers to "mean" or average AirCell signal levels in its assessment of harmful interference to terrestrial cellular AMPS systems.[38] However, it should be noted that the analysis of "mean" signal levels, as averaged over a distance that does not correspond to an appropriate unit of measure, is not meaningful.

For example, in considering a flight path from New Jersey to Florida and the received signal levels at only one victim terrestrial site in NJ, the average signal level received for this flight path is meaningless. Much of the flight path is not in the vicinity of the cell site, and averaging over this distance (flight path to the victim site) does not have any meaningful significance. The same is true for the mean signal levels presented in the AirCell 1997 flight data.

Once the aircraft is outside half the frequency reuse distance of the terrestrial site, the data should not continue measuring and average signal levels that are lower and closer to the noise floor of the base station (i.e. where the aircraft is farther from the terrestrial site). Analysis of mean signal strength of the entire flight path is technically flawed.

In contrast, if the FCC were to analyze the mean signal level, as averaged over one half the distance of typical cellular frequency reuse patterns, this would be a useful method of analysis. This represents the distance over which the cellular channel is used by the cellular system for one victim cell site, and does not extend into the area that is using the same channel by the next cell site.

V-COMM conducted an extensive survey of cellular sites (over 1,200 cellular sites) in the New Jersey, Philadelphia, PA and surrounding market areas, and observed the average distance between adjacent cellular sites as 0.64, 1.8, 3.1, and 6.0 miles, for the market environments of dense urban, urban, suburban, and rural, respectively. The radius of the cell sites is half the distance between the sites, or 0.32, 0.9, 1.55, and 3.0 miles, respectively. For AMPS cellular systems utilizing a N=7 frequency reuse pattern, half the distance of the reuse pattern (D) is equal to:

$$\tfrac{1}{2} D = (4.6\ R) / 2 \qquad \text{R is the radius of the cell site}$$

For the radius of cell sites above, half the distance between cellular sites that utilize the same frequency channel are 0.74, 2.1, 3.6, and 6.9 miles, for sites in dense urban, urban, suburban, and rural markets, respectively. Therefore, meaningful analysis of "mean" AirCell signal levels would be reference to these distances from terrestrial sites,

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[38] Order on Remand, on Pg. 11-12, in paragraphs 24 through 26.

which are significantly less than the averaged distance utilized and reported in the AirCell 1997 report.

6.2 FCC's description of Airtouch's ITL Derivation is Inaccurate

Airtouch's ITL for the rural environment is -124 dBm level, which is where masthead electronics is assumed. To attain –124 dBm, Airtouch assumed -127 dBm system noise floor for base stations with masthead electronics, plus Airtouch's fade margin of 4.76 dB, which equals –122.24 dBm. Then, minus Airtouch's interference margin of 1.76 dB (this equates to Airtouch's allowed 2.2 dB or 66% increase in total noise for rural markets only). This assumes Airtouch's rural sites with mastheads would incur a 2.2 dB increase in total noise levels, which results in a total noise level of –120 dBm (-122.24 dBm + 2.2 dB). For all other environments, Airtouch replaced the 1.76 dB with the required 10 dB (isolation required to prevent a 0.5 dB or 10% increase in total noise floor). So, for other environments with Airtouch stated noise floors of: Suburban -117, Urban -112, Noisy Urban -104 dBm, this yields the Airtouch ITL for these environments: -122, -117, -109 dBm, respectively. Airtouch's justification for the increase in allowable interference for rural systems with mastheads (from 10% to 66%) was because the 10 dB requirement is too stringent in rural applications since it results in an ITL of –132 dBm, which is below the thermal noise floor. That is Airtouch's explanation in record.

In the Order, the FCC's description of Airtouch's ITL derivation is slightly differently.[39] The FCC stated that –124 dBm was derived from –127 dBm plus –124 dBm, which equals a total noise increase to –122.24 dBm. However, as indicated above, Airtouch's total allowable noise level for rural markets is –120 dBm, and –124 dBm ITL is calculated by –127 dBm plus the 4.76 dB fade margin, minus 1.76 dB. The 1.76 dB interference margin limits the noise floor increase to 66% above the system noise floor plus the fade margin, and thus allows a 2.2 dB increase in noise floor for the rural case resulting in a total noise level of –120 dBm.

6.3 FCC's Assessment of Worst Case Scenario is Incorrect

In the Order,[40] the FCC stated that it did not rely upon a probability study, but instead assumed simultaneous channel use would occur, and considered the results of a worst case scenario. In its analysis, the FCC assumed the worst case scenario is with an AirCell equipped aircraft flying directly above a victim terrestrial site. However, it should be noted, as explained in an earlier section and in V-COMM's Engineering Response, that this is the best case scenario because of the nulls in the terrestrial antenna and AirCell VOR mobile antenna patterns. Consequently, the FCC did not consider the worst-case flight path scenario in its assessment of the AirCell system. Also, it did not

[39] Order on Remand, Pg. 9, Paragraph 19, and footnote 52.

[40] Order on Remand, Pg. 13, Paragraph 27-28, and footnote 71.

consider the worst-case victim terrestrial site antenna, which is slant 45 degree or horizontally polarized, in its assessment.

6.4 AirCell's Use of DPC Does Not Lessen Concerns of Interference

In the Order, the FCC states the AirCell system incorporates a number of safeguards, such as Dynamic Power Control (DPC), to prevent harmful interference.[41] However, it should be noted that AirCell's DPC function solely relies upon providing sufficient signal strength to maintain adequate service for AirCell customers, and is entirely independent of the needs of the terrestrial cellular system. The AirCell DPC feature will not reduce the likelihood of harmful interference since AirCell mobiles will likely transmit at maximum power levels in neighboring markets and at lower altitudes.

With the DPC feature, AirCell phones are likely to be at the maximum power level (75 mW, per FCC waiver limits) when flying furthest from the AirCell serving site. Thus, when an airborne AirCell phone is operating within a neighboring market, further away from its AirCell serving site, the AirCell phone will likely operate at its maximum power levels. Also, when flying at the lower elevations, i.e. below 5,000 feet, the AirCell phone can operate at maximum levels due to increased propagation losses associated with foliage and building obstructions to the signal path's fresnel zone.

However, these are the two most critical times for causing interference to terrestrial systems, that is, at these times, AirCell phones should be operating at their lowest levels to prevent interference. On the other hand, when AirCell phones are in the vicinity of their serving cell site – when lower power is least needed – the DPC will cause the AirCell phones to operate at lower power levels. In summary, AirCell's DPC will provide an improvement when least needed and will *not* provide an improvement when it is needed most. For those reasons, it does not lessen cellular service operator's concerns of interference.

In addition, since AirCell's DPC is independent of the needs of an interfered-with cellular system, it can operate at maximum power levels in areas where the interfered-with cellular system has the lowest noise floors. Again, the DPC feature does not lower power when the interfered-with cellular system requires it, only when the AirCell phone is closer to its home system serving site. For areas remote from the home serving cell site, there is no reduction in the likelihood of interference.

If DPC is not properly configured, AirCell will operate all its calls near the maximum power levels. The DPC feature is controlled by a setting in the switch known as the "target RSSI" setting. The operating value setting for the "Target RSSI" will be dependent on the particular market, the channel reverse link noise floor and AirCell's C/I criteria. This can vary by market, site, channel group, and other factors. In optimizing

[41] Order on Remand, Pg. 2, footnote 8.

the performance of the AirCell system, the AirCell DPC levels are set to maintain acceptable quality service for AirCell customers.

7 Appendix

7.1 V-COMM Background Information

V-COMM is a leading provider of quality engineering and engineering related services to the worldwide telecommunications industry. V-COMM's staff of engineers are experienced in Cellular, Personal Communications Services (PCS), Enhanced Specialized Mobile Radio (ESMR), Paging, Wireless Data, Microwave, Signaling System 7, and Local Exchange Switching Networks. Further, V-COMM was selected by the FCC & Department of Justice to provide expert analysis and testimony in the Nextwave and Pocket Communications Bankruptcy cases. V-COMM has offices in Blue Bell, PA and Cranbury, NJ and provides services to both domestic and international markets. For additional information, please visit V-COMM's web site at www.vcomm-eng.com.

Biographies of Key Individuals

Dominic C. Villecco
President and Founder
V-COMM, L.L.C.

Dominic Villecco, President and founder of V-COMM, is a pioneer in wireless telecommunications engineering, with 22 years of executive-level experience and various engineering management positions. Under his leadership, V-COMM has grown from a start-up venture in 1996 to a highly respected full-service consulting telecommunications engineering firm.

In managing V-COMM's growth, Mr. Villecco has overseen expansion of the company's portfolio of consulting services, which today include a full range of RF & Network design, engineering & support; network design tools; measurement hardware; and software services; as well as time-critical engineering-related services such as business planning, zoning hearing expert witness testimony, regulatory advisory assistance, and project management.

Before forming V-COMM, Mr. Villecco spent 10 years with Comcast Corporation, where he held management positions of increasing responsibility, his last being Vice President of Wireless Engineering for Comcast International Holdings, Inc. Focusing on the international marketplace, Mr. Villecco helped develop various technical and business requirements for directing Comcast's worldwide wireless venture utilizing current and emerging technologies (GSM, PCN, ESMR, paging, etc.).

Previously he was Vice President of Engineering and Operations for Comcast Cellular Communications, Inc. His responsibilities included overall system design, construction and operation, capital budget preparation and execution, interconnection negotiations, vendor contract negotiations, major account interface, new product implementation, and cellular market acquisition. Following Comcast's acquisition of Metrophone, Mr. Villecco successfully merged the two technical departments and managed the combined department of 140 engineers and support personnel.

Mr. Villecco served as Director of Engineering for American Cellular Network Corporation (AMCELL), where he managed all system implementation and engineering design issues. He was responsible for activating the first cellular system in the world utilizing proprietary automatic call delivery software between independent carriers in Wilmington, Delaware. He also had responsibility for filing all FCC and FAA applications for AMCELL before it was acquired by Comcast.

Prior to joining AMCELL, Mr. Villecco worked as a staff engineer at Sherman and Beverage (S&B), a broadcast consulting firm. He designed FM radio station broadcasting systems and studio-transmitter link systems, performed AM field studies and interface analysis and TV interference analysis, and helped build a sophisticated six-tower arrangement for a AM antenna phasing system. He also designed and wrote software to perform FM radio station allocations pursuant to FCC Rules Part 73.

Mr. Villecco started his career in telecommunications engineering as a wireless engineering consultant at Jubon Engineering, where he was responsible for the design of cellular systems, both domestic and international, radio paging systems, microwave radio systems, two-way radio systems, microwave multipoint distribution systems, and simulcast radio link systems, including the drafting of all FCC and FAA applications for these systems.

Mr. Villecco has a BSEE from Drexel University, in Philadelphia, and is an active member of IEEE. Mr. Villecco also serves as an active member of the Advisory Council to the Drexel University Electrical and Computer Engineering (ECE) Department.

Relevant Expert Witness Testimony Experience

Over the past five years, Mr. Villecco had been previously qualified and provided expert witness testimony in the states of New Jersey, Pennsylvania, Delaware and Michigan. Mr. Villecco has also provided expert witness testimony in the following cases:

> United States Bankruptcy Court
>
> Nextwave Personal Communications, Inc. vs. Federal Communications Commission (FCC) **
>
> Pocket Communications, Inc. vs. Federal Communications Commission (FCC) **

** In these cases, Mr. Villecco was retained by the FCC and the Department of Justice as a technical expert on their behalf, pertaining to matters of wireless network design, optimization and operation.

David K. Stern
Vice President and Co-Founder
V-COMM, L.L.C.

David Stern, Vice President and co-founder of V-COMM, has over 20 years of hands-on operational and business experience in telecommunications engineering. He began his career with Motorola, where he developed an in-depth knowledge of wireless engineering and all the latest technologies such as CDMA, TDMA, and GSM, as well as AMPS and Nextel's iDEN.

While at V-COMM, Mr. Stern oversaw the design and implementation of several major Wireless markets in the Northeast United States, including Omnipoint - New York, Verizon Wireless, Unitel Cellular, Alabama Wireless, PCS One and Conestoga Wireless. In his position as Vice President, he has testified at a number of Zoning and Planning Boards in Pennsylvania, New Jersey and Michigan.

Prior to joining V-COMM, Mr. Stern spent seven years with Comcast Cellular Communications, Inc., where he held several engineering management positions. As Director of Strategic Projects, he was responsible for all technical aspects of Comcast's wireless data business, including implementation of the CDPD Cellular Packet Data network. He also was responsible for bringing into commercial service the Cellular Data Gateway, a circuit switched data solution.

Also, Mr. Stern was the Director of Wireless System Engineering, charged with evaluating new digital technologies, including TDMA and CDMA, for possible adoption. He represented Comcast on several industry committees pertaining to CDMA digital cellular technology and served on the Technology Committee of a wireless company on behalf of Comcast. He helped to direct Comcast's participation in the A- and B-block PCS auctions and won high praise for his recommendations regarding the company's technology deployment in the PCS markets.

At the beginning of his tenure with Comcast, Mr. Stern was Director of Engineering at Comcast, managing a staff of 40 technical personnel. He had overall responsibility for a network that included 250 cell sites, three MTSOs, four Motorola EMX-2500 switches, IS-41 connections, SS-7 interconnection to NACN, and a fiber optic and microwave "disaster-resistant" interconnect network.

Mr. Stern began his career at Motorola as a Cellular Systems Engineer, where he developed his skills in RF engineering, frequency planning, and site acquisition activities. His promotion to Program Manager-Northeast for the rapidly growing New York, New Jersey, and Philadelphia markets gave him the responsibility for coordinating all activities and communications with Motorola's cellular infrastructure customers. He directed contract preparations, equipment orders and deliveries, project implementation schedules, and engineering support services.

Mr. Stern earned a BSEE from the University of Illinois, in Urbana, and is a member of IEEE.

Sean Haynberg
Director of RF Technologies
V-COMM, L.L.C.

Sean Haynberg, Director of RF Technologies at V-COMM, has over 13 years of experience in wireless engineering. Mr. Haynberg has extensive experience in wireless system design, implementation, testing and optimization for wireless systems utilizing CDMA, TDMA, GSM, AMPS and NAMPS wireless technologies. In his career, he has conducted numerous first office applications, compatibility & interference studies, and new technology evaluations to assess, develop and integrate new technologies that meet industry and FCC guidelines. His career began with Bell Atlantic NYNEX Mobile, where he developed an in-depth knowledge of wireless engineering.

While at V-COMM, Mr. Haynberg was responsible for the performance of RF engineering team supplying total RF services to a diverse client group. Projects varied from managing a team of RF Engineers to design and implement new a PCS wireless network in the NY MTA; to the wireless system design & expansion of international markets in Brazil and Bermuda; to system performance testing and optimization for numerous markets in the north and southeast; to the development and procurement of hardware and software engineering tools; to special technology evaluations, system compatibility and interference testing. He has also developed tools and procedures to assist carriers in meeting compliance with FCC rules & regulations for RF Safety, and other FCC regulatory issues. In addition, Mr. Haynberg was instrumental in providing leadership, technical analysis, engineering expertise, and management of a team of RF

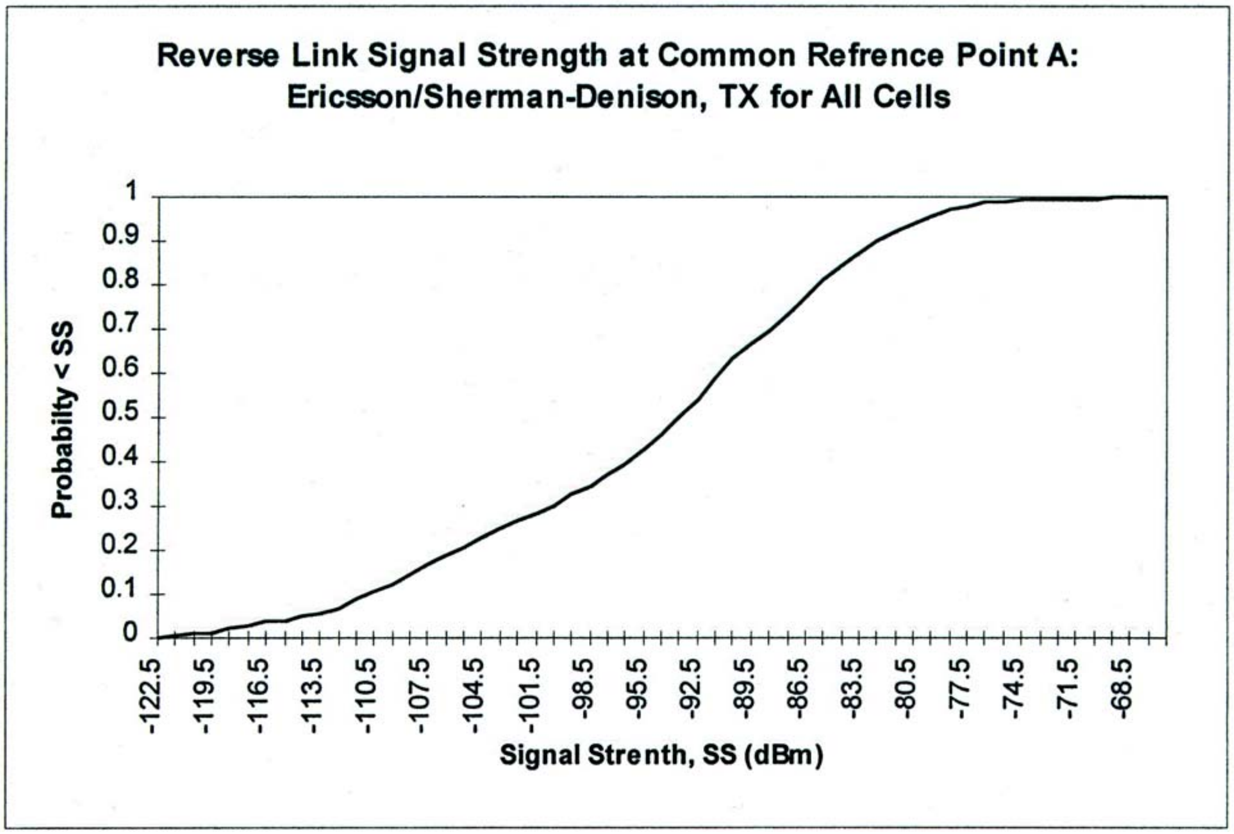
Engineers to deliver expert-level engineering analysis & reporting on behalf of the FCC & Department of Justice, in the Nextwave and Pocket Communications Bankruptcy proceedings.

Prior to joining V-COMM, Mr. Haynberg held various management and engineering positions at Bell Atlantic NYNEX Mobile (BANM). He was responsible for evaluating new technologies and providing support for the development, integration and implementation of first office applications (FOA), including CDMA, CDPD, and RF Fingerprinting Technology. Beyond this, Haynberg provided RF engineering guidelines and recommendations to the company's regional network operations, supported the deployment and integration of new wireless equipment and technologies, including indoor wireless PBX/office systems, phased/narrow-array smart antenna systems, interference and inter-modulation analysis and measurement, and cell site co-location and acceptance procedures. He was responsible for the procurement, development and support of engineering tools for RF, network and system performance engineers to enhance the system performance, network design and optimization of the regional cellular networks. He began his career as an RF Engineer responsible for the system design and expansion of over 100 cell sites for the cellular markets in New Jersey, Philadelphia, PA; Pittsburgh, PA; Washington, DC; and Baltimore, MD market areas.

Mr. Haynberg earned a Bachelor of Science degree in Electrical Engineering with high honors, and attended post-graduate work, at Rutgers University in Piscataway, New Jersey. While at Rutgers, Mr. Haynberg received numerous honors including membership in the National Engineering Honor Societies Tau Beta Pi and Eta Kappa Nu. In addition, Mr. Haynberg has qualified and provided expert witness testimony in the subject matter of RF engineering and the operation of wireless network systems for many municipalities in the state of New Jersey.

7.2 AT&T Terrestrial Customer Signal Strength Measurements in 1997 Record

Figure 7-A Reproduction of AT&T's Figure 8: Uplink Carrier CDF for Sherman-Denison, 2261 data points, Approx. 10 Cells (submitted to Commission on Dec. 15, 1997)



7.3 V-COMM Case Study Flight Profile and Affected Terrestrial Cell Sites

Figure 7-B Flight Profile & Affected Terrestrial Sites, Slant-45 Terrestrial Antenna, Average Signal Level, IAP –110 dBm

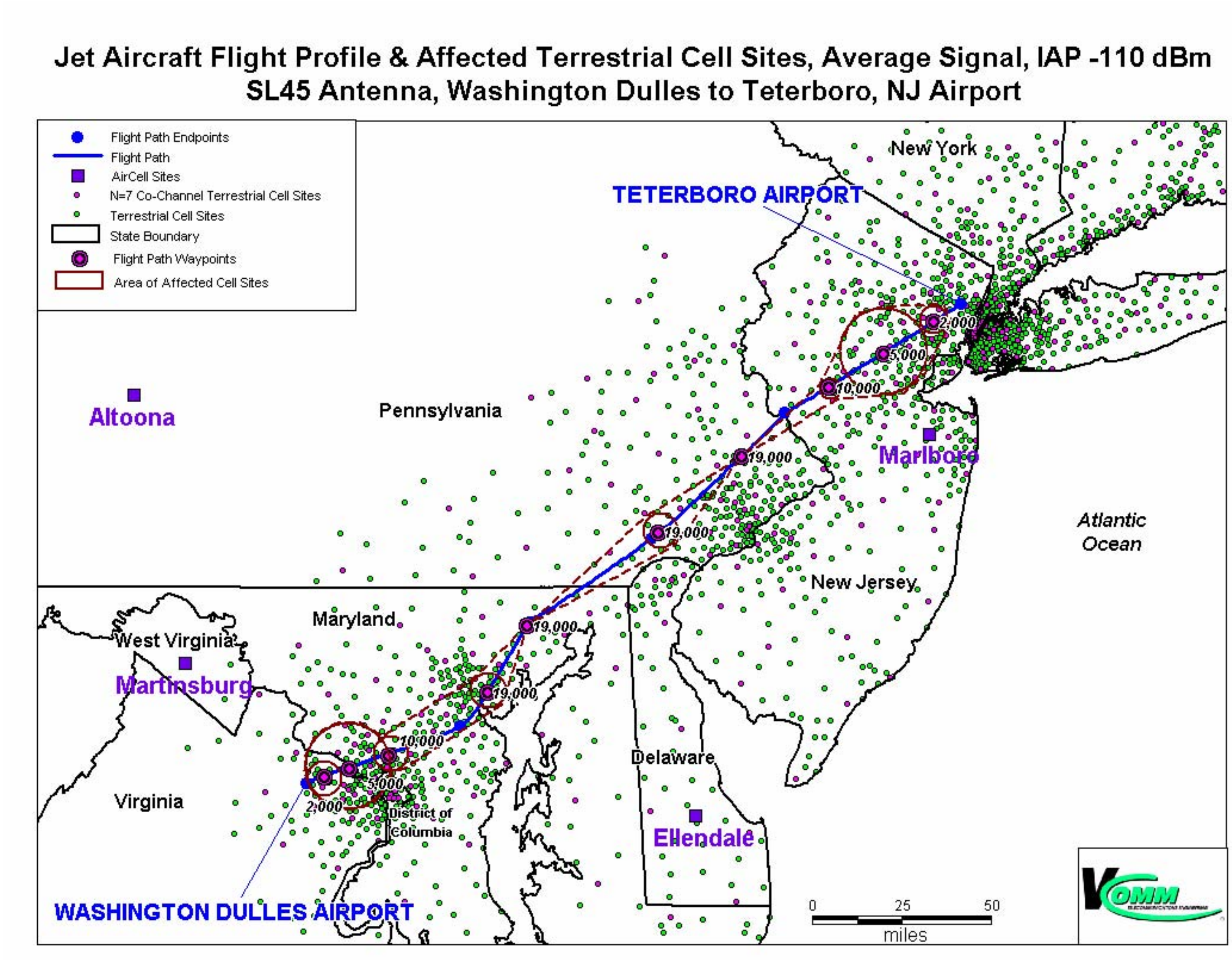


Figure 7-C Flight Profile & Affected Terrestrial Sites, Slant-45 Terrestrial Antenna, 90% Signal Level, IAP –110 dBm

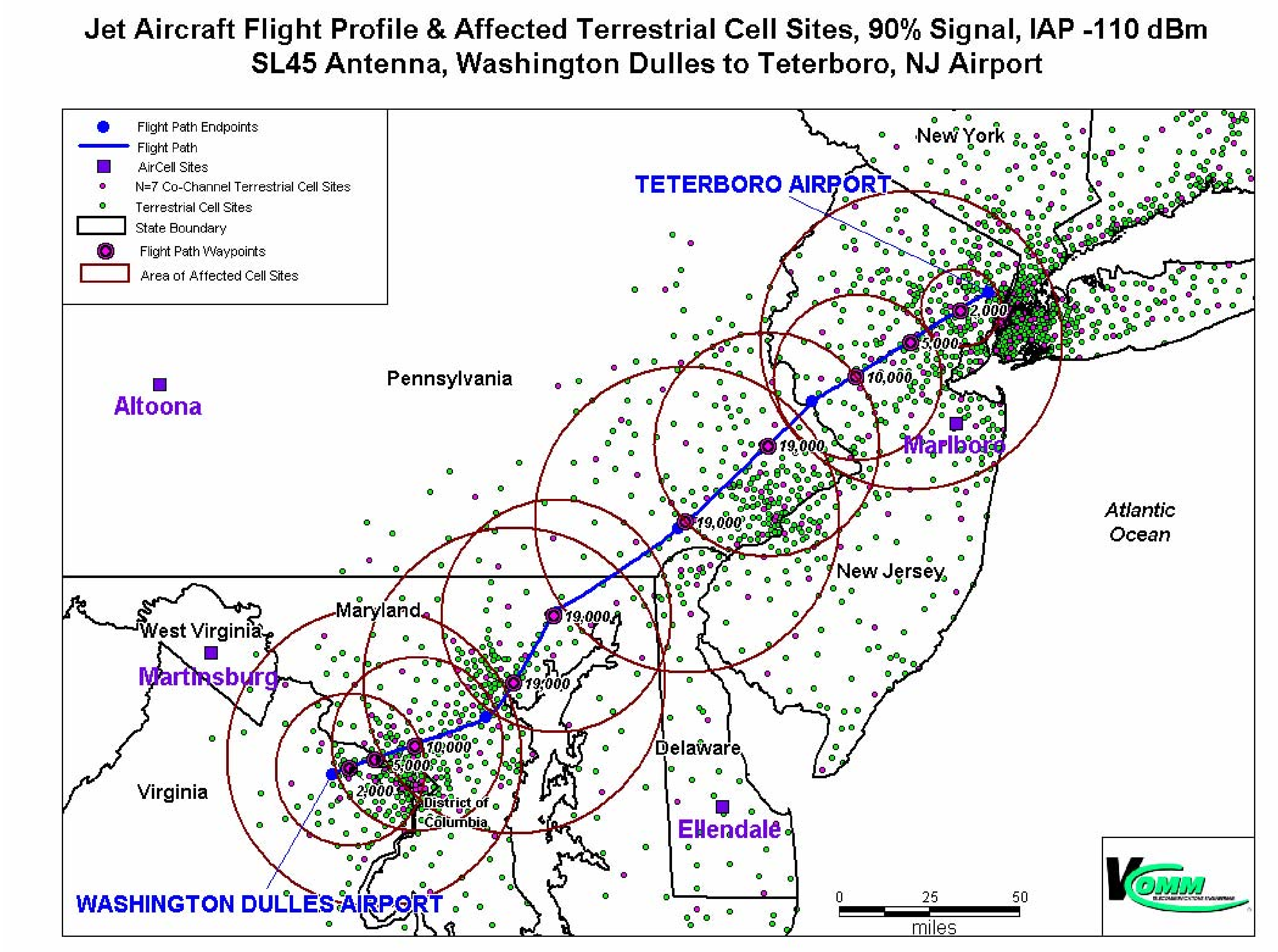


Table 7-A Data Sheet Analysis of Case Study: Affected Terrestrial Cell Sites, Slant-45 Terrestrial Antenna, -110 dBm IAP

Affected Terrestrial Cell Sites along flight path DC to NJ, for SL45 Terrestrial Antenna, Jet Aircraft, -110 dBm Interference Analysis Point

Flight Waypoint #	Airplane Altitude (ft, AMSL)	Airplane Distance (mi) Fm Dulles	Airplane Distance (mi) Fm Teterboro	AirCell Serving Site [5]	Distance Fm AirCell Serving Site	AirCell [2] Mobile DPC Level	dB Offset [3] for RSSI	Distance (mi) [1] to Terrestrial Site Average	Distance (mi) [1] to Terrestrial Site 90%	Average RSSI # of Affected Terrestrial Sites [4] Total	Average RSSI # of Affected Terrestrial Sites [4] 1/7 Total	90% RSSI # of Affected Terrestrial Sites [4] Total	90% RSSI # of Affected Terrestrial Sites [4] 1/7 Total
1	2,000	5	219	WV	50	4	-8	5	21	12	2	188	27
2	5,000	12.5	211.5	WV	55	3	-4	12	41	103	15	378	54
3	10,000	25	199	WV	63	3.25	-5	5	24	16	2	271	39
4	19,000	57	167	WV	82	3	-4	5	42	13	2	313	45
5	19,000	79	145	DE	71	3.5	-6	0	32	0	0	120	17
6	19,000	123	101	DE or NJ	80	3	-4	5	42	5	1	280	40
7	19,000	151	73	NJ	51	4	-8	0	31	0	0	232	33
8	10,000	181	43	NJ	31	4	-8	3	23	3	0	113	16
9	5,000	199	25	NJ	27	3	-4	12	41	71	10	710	101
10	2,000	215	9	NJ	32	5.75	-15	4	11	8	1	96	14
				Average =	54.2	3.7	-6.6	5.1	30.8	23	3	270	39
				Std. Dev.=	20.0	0.9	3.4	4.1	10.8	35	5	180	26
									Total Affected Terrestrial Cell sites,[4]: With An Interference Threshold of -110 dBm	**302**	**43**	**1292**	**185**

Notes for Table (above):

1. The data sheet above represents the number and distances to the affected terrestrial cell sites for the the Phase 1 Flight Test Results. An Interference Analysis Point (IAP) of -110 dBm for AMPS, TDMA & CDMA technologies is used to determine the approximate distance for consistent AirCell Signal Levels. These are the distances from the Airplane to the terrestrial cell site, using the IAP as a threshold, the pathloss (AirCell signal strength) from the DPC Disabled Flight Tests, and the average AirCell Mobile DPC level from DPC Enabled flight tests. The Average and 90% RSSI Levels, from the DPC Disabled flight tests graphs for the specified flight altitudes and airplanes, are used to determine the distances to the signal level crossing. A RSSI "dB Offset" for AirCell mobile Tx Power is observed from the DPC Enabled flight test results. The resultant distances are the radius' of the circles for the Flight Map Exhibit, with Affected Terrestrial Cell Sites.

2. This analysis uses the "average" AirCell mobile DPC level, as observed for the "Average DPC Levels" line from the DPC Enabled flight test results. These AirCell mobile DPC levels are observed for the specified flight altitudes, airplanes and distances from the AirCell Marlboro, NJ site.

3. This analysis uses a "dB Offset for RSSI", which is assessed from the "Average DPC Levels" from flight tests with DPC Enabled. For this analysis, this dB value is used to lower the AirCell signals levels received at the terrestrial site, from the Phase 1 Flight Test Results for the DPC Disabled Flight Tests.

4. The Total # of Affected Terrestrial Sites are computed from the "airplane to terrestrial cell" Distances, for the Average or 90% Signal Levels, as listed above. The Total and 1/7 Total data is computed from the cell sites on Flight Map Exhibit with Affected Terrestrial Cell Sites. The "Total Affected Terrestrial Cell sites" are unique, which have the duplicated cell sites removed from the individual waypoint counts for the overlapping circles.

5. This analysis uses the closest AirCell site as the serving AirCell site for each waypoints above, which assumes that the AirCell airborne mobile will be at a more conservative DPC level, which is at lower power.